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ABSTRACT

An exploratory study of what 5- and 6-year-old children can and will do when provided with certain kinds of computer experiences is described. The purpose of the study was to determine whether tutee programs can engage and sustain the learning energy of 5-year-olds. A total of 22 kindergarten children attended 8 or 12 90-minute sessions at a computer laboratory. The activity program was set up to provide, on a free-choice basis, computer activities via LOGO programming and other learning activities. Findings indicated that (1) computers can be used to help meet curriculum goals under certain circumstances; (2) computer activities, in which the command system is sufficiently simple and directly related to events on screen, offer the opportunity for children to experiment and learn on their own terms; and (3) nonreaders and young children with overriding interests in the three-dimensional world are not likely to use the computer as more than a novelty toy. Contributing to the development of a model for computer use by kindergarten children, seven conditions are listed that engage and sustain the learning energies of some children. It is concluded that microcomputers do not yet belong in early childhood classrooms serving 3- to 6-year-old children. The Afterword examines two additional points generated by the study: (1) The concept of 'designed boundaries' provides a useful model for planning and developing technology-related experiences. (2) Making critical decisions on the use of technology in the classroom requires a sound understanding of the knowledge base of education; hence for staff, knowledge of technology should follow knowledge of the teaching process. (RH)

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EDUCATORS A MONOGRAPH SERIES

Microcomputers and Young Children

An Exploratory Research Study

by Sydney Schwartz

Afterword

by Daniel James Brovey

School of Education
Queens College of the City University of New York

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What is to be taught, to whom, and in what manner? The rash of recent national reports on education seems by and large free of any effort to reflect seriously on these perennial questions. Indeed, from reading the reports, one would think that the great questions have already been answered: more time on task, more science and math, tougher grading, preparation for a competitive society. Yes, but. The prescriptions are being offered with little thought about the larger context in which educating goes on.

With this series of occasional papers, the Queens College School of Education seeks to broaden professional dialogue. Our writers will take stands. They will examine goals as well as curriculum issues and designs. They will welcome critical response, along with the raising of further questions. To ask is half to know.

William A. Proefriedt

ISSUES FOR EDUCATORS A MONOGRAPH SERIES

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School of Education
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Microcomputers and Young Children
An Exploratory Research Study[1]

Sydney L. Schwartz
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This paper is a report, an appeal, and a statement. It describes an exploratory research study about what five- and six-year-old children can and will do when provided with certain kinds of computer experiences. It makes an appeal to early childhood educators to become actively involved in accumulating necessary research information for decision-making that may affect the future of their profession. Finally, it states a position on the use of microcomputers in early childhood programs.

Rarely in the history of public education has such a powerful, pervasive enthusiasm swept the professional community and parents' groups alike as the current support for placing computers in schools. Interest in using computers for instructional purposes has become so extensive that it now includes the least likely group of learners—early childhood classes serving nonreaders and beginning readers. As a result of this wave of enthusiasm, politically sensitive school boards are rushing into educational policy decisions without adequate supportive data. The haste with which large sums of educational dollars are allocated for classroom computers highlights the need to initiate research quickly.

The problem is compounded at the lower end of the educational spectrum, since younger school groups are particularly vulnerable to poor educational experiences. Many early childhood specialists have shunned involvement with computer research because they are strongly convinced that computers will not appropriately serve the developmental needs of young children.[2] They further anticipate that the introduction of this new technology into the world of nonreaders and beginning readers will interfere with normal learning interests associated with the early school years.[3] In the absence of supportive data, however, such convictions become very hard to defend.

If the early childhood professional community does not establish a cadre of computer-knowledgeable educators within its own ranks, others, who do not understand the unique qualities of young children, will make the decisions about the "When?", "Where?" and "How?" of computer usage for this age group.[4] Said another way, if a choice must be made between two unsupported views—one which says that computers do not belong in classrooms for young children and the more pervasive view that *all* school-age children need to get started with the computer as soon as possible—the curriculum leadership role is likely to be assumed by other than early childhood persons.

Clarifying the Research Questions

The essential questions educators need to answer in order to make informed decisions about using the microcomputer are: "Can the use of the microcomputer help to meet curriculum goals?" and "If so, which goals?" Without violating convictions about young children's needs for an action-based learning environment, exploratory research with the computer can be designed to find out generally what young children do when provided with computer experiences. From this broad-based, descriptive information, we can begin to establish a set of answers to the question of what's possible under given conditions. Despite the impatience of researchers to obtain data from formal studies, exploratory forms of research are a necessary prerequisite, for they serve as a basis for generating the more limited and precise questions needed for formal studies.

Distinguishing the Computer from Other Instructional Materials in Early Childhood

A first step toward an exploratory research design is to analyze the differences between computer experiences and those with conventional early childhood materials. When children play with early childhood materials such as kindergarten building blocks, they immediately obtain information from their actions without direct instruction from the teaching adult. This information usually leads comfortably to some success with bunching and piling, and to an intuitive understanding of physical laws relating to balance and weight which govern block constructing. Similarly, most basic materials for the graphic and plastic arts and for dramatic play can be readily used without initial instruction.[5] Only games and some craft materials require instruction from a knowledgeable person.

In contrast to learning through self-directed action, as with concrete materials such as those illustrated above, there is no way the nonreading child can achieve initial success with the computer without help from someone who knows how to run the program or knows how to read. The novice cannot learn how to communicate with the computer, that is, speak its language, through exploration and manipulation alone.

The learning challenges presented to young children by the computer vary considerably, depending upon the software and computer language presented. A helpful framework for categorizing the different uses of a computer is the "Tool, Tutor or Tutee" analysis suggested by Robert Taylor.[6] The *tutor* use requires software in which the machine assumes the teaching role. For young children, tutor programs focus on acquisition of the basic academic skills associated with beginning reading, writing, and arithmetic. Essentially, these programs represent the drill-and-practice model. In traditional early childhood classrooms, the teacher directs drill and practice, supported by specially selected follow-up games and activities.

The *tutee* approach looks to children's construction of their own learning experiences by using a computer language with which to design their own drawings, games, or other self-selected tasks. Here, the child is viewed as the teacher of the computer. By using the language of the computer, the child instructs the computer to complete specific procedures.[7] This approach is often referred to as *interactive*, because the child becomes a necessary participant in deciding what to do next, and how to do it. The LOGO turtle graphics or drawing program is the most frequently cited interactive program for younger children.

Finally, using the computer as a *tool* includes such activities as word processing, data management, and mathematical computation. This approach may serve schools' writing goals for beginning readers, fostering growth in written language skills and the expression of ideas.[8] Combination of word processing and other programming capabilities of the computer has led to the design of linked beginning-level reading and writing programs. In the traditional early childhood classroom, writing takes the form of experience charts handwritten by the adult, and data management occurs with simple graphs and charts jointly produced by teacher and children.

The lack of firm data on the advantages of each of these three uses of the computer with young children is more encouraging than discouraging, for it provides a great deal of latitude while simultaneously imposing a responsibility to view initial research findings as tentative. Given the conditions described above, the author invited Mrs. Rochelle Leibson, a district-based early childhood Computer Resource

Teacher, to join her in designing and implementing the following exploratory research study at Queens College during the academic year 1983-4.[9]

Designing and Testing a Model

Our purpose was to find out whether *tutee* programs can engage and sustain the learning energy of five-year-olds. It was our conviction that there was no need to expand drill programs, and that the computer would not provide economically efficient drill practice for young children in school. We did, however, recognize a need to develop more and better ways to stimulate children's thinking, to foster cognitive development; and we believed that the computer might prove a useful curriculum resource to help reach this goal.

The cognitive developmentalist view characterizes the early childhood stage as one in which children build understandings through their own actions. Important attributes of this growth period include a dependence upon the way things *seem* to look, in contrast to logic; limited understanding of cause-effect relationships, marked by animistic thinking to explain events for which causes are not visible; a limited ability to link multiple events; and a relative lack of skill with the written symbol-system of our culture. These qualities represent where young children are in the spectrum of growth from childhood to adult thinking, and highlight the kinds of experiences from which they can build understandings. From a curriculum-design perspective, these characteristics established the boundaries of our design for research on the use of computer activities, i.e. ones for which children can see a direct, visible relationship between what they do and what happens.[10]

Goals

We designed our project to explore ways of using the microcomputer as a means of stimulating cognitive processing, while also conforming with the characteristics of the early childhood developmental period. Cognitive processing features observation, identification, and manipulation of variables to achieve a variety of goals. Since we would be using a computer lab, we also found it possible to look at the potential for using a computer room as the primary site for computer use by young children.

The questions we asked were: "Can computer experiences engage and sustain the attention of young children as active learners? If so, what classroom conditions seem to be associated with successful involvement of the children?"

Assumptions

The following assumptions about how young children learn guided the design process:

1. *Young children are more likely to incorporate what they are currently learning into their own reservoir of knowledge if the learning serves their own goals.* That is, they learn best what they choose to learn.

2. *Young children will sustain interest and focus attention longer on tasks they select for themselves and can work through at their own speed.* To classify as a self-selected task, the task must be chosen from a set of attractive options so that the selection is genuine, not by default.

3. *Challenging activities for which young children have limited skills will hold their interest for only relatively short time-cycles, of ten to twenty minutes.* If the activity is genuinely engaging, however, and they succeed in gaining increasing mastery with each encounter, they will return *by choice*, extending the length of involvement as they find they can do more.

We selected the kindergarten age group for the study, as the midpoint of early childhood. Five-year-olds, if they have not already developed beginning reading and mathematics skills and understandings, are on the brink of so

doing. It seemed likely that we would have both nonreaders and beginning readers in such an age group, thus allowing us to look at a representative sample of academic skill development. Additionally, this age group is the one most likely to be found in both public and private early childhood classes. Thus the findings might serve a broad range of educational settings.

Activity Choices

The following design reverses the idea of using the computer as supplemental to the regular classroom resources. Instead, it uses the traditional early childhood classroom materials as supplements to a computer-room experience.

We selected LOGO as the primary computer program, due to two of its major characteristics: (1) the emphasis on decision-making by the child, as integral to the computer experience, and (2) the ease with which children can produce effects, while also avoiding the theatrics of much of the tutor-type software. Since we were working with five-year-olds, who have limited command of both the written language and our number system, we modified LOGO language to a Keystroke format. This simplified form requires the use of only one key for a command, along with the Return key to execute the selected command. Keystroke LOGO establishes the basis for relatively easy transition to regular LOGO when the children have greater command of basic skills. To add variety to the LOGO drawing experiences and to stimulate greater use of the drawing commands, we provided additional activities, which included targets, mazes, picture task-cards, a dot grid, and incomplete shapes on screen.

To increase the choices available, we selected a few software packages that we felt provided an opportunity to manipulate variables, avoiding those programs that give extensive payoff for very little investment of learning energy. One was a segment of Kindercomp (Spinnaker) entitled DRAW, in which children create pictures by using a cursor to place rectangles on screen. Another was Moptown Parade (Learning Company), which features identification and manipulation of object attributes. Since the laboratory housed fifteen microcomputers, we could plan to provide one computer per child with LOGO, as well as other programs on the extra machines.

Another set of activity choices included some of the familiar early childhood classroom materials, such as kindergarten blocks and accessories, crayons and paper, small colored one-inch cube blocks, and hand puppets. The provision of these kindergarten materials assured a set of materials with which children were already competent, and could exercise their need to work with what was familiar. A third set of choices included computer-related activities with concrete materials and games. We had two Big Traks, programmable floor toys in the shape of a tank, and several board games and activities that featured the use of the two variables of number and direction.

Setting up the Group

As already indicated above, the Apple Computer Laboratory at Queens equipped with fifteen microcomputers and two printers served as the project site. The light and airy room was sufficiently large to accommodate other activities within it, using both table space and floor space.

For greater ease of management, we conformed with an existing Saturday morning children's program, which charged a modest fee for providing eight weekly 90-minute sessions. The two researchers, both early childhood specialists with computer training, served as teachers for the class.

The children came from all over the borough of Queens, which represents a cross section of urban groups. Children were enrolled on a first-come first-served basis. Considerable screening was imposed by the conditions of (a) a fee, (b) the midday Saturday schedule, and (c) classtime of 90 minutes between dropoff and pickup. Only highly motivated parents, willing and able to spend the time and money for their five-year-olds, would be likely to enroll their child. We could not make assumptions, however, about measured intelligence, social maturity, or level of acquisition of beginning academic skills, although it seemed likely that we would be working with a normal range. We enrolled 10 kindergarten children for the first eight-week cycle. In the next cycle we enrolled a totally new group, increasing the group size to 12. For one third cycle, we selected 11 children from the first two groups, to participate in an additional eight sessions.

Teaching Strategies

We planned to have only one or two brief total-group introductory sessions and then confine our strategies to the kinds of teaching interactions usually associated with multiple-activity classrooms. These included: (a) responding to children's requests for help, information, and sharing of experiences; (b) intervening with suggestions and ideas, as needed to facilitate further exploration and to avoid continual failure; and finally (c) dealing with the standard classroom-management needs, and children's social-emotional needs.

Data Collection

During the first cycle, we restricted our data collection to teacher entries on observation charts, noting at regular interviews which materials each child was using, the social context, and the form of the learning endeavor. Additionally, we kept two audiotape recorders running throughout each session.

During the second eight-week cycle, an independent observer recorded the sequence of children's activities on and off the computer, and some of the learning challenges that captured their attention. We continued to audiotape the sessions, increasingly using the tape recorder to record data on duration of activity, substance of activity, children's questions, and comments that reflected their understanding and our reactions to events that were occurring.

For the final eight-week session, we videotaped some of the sessions, in order to capture more of the dynamics of children's interactions and garner nonverbal messages we would otherwise miss. Use of the audiotape recorders, as well as of an observer, continued.

Findings

Our data lend themselves to much detailed analysis in the future, but some patterns are already clearly evident.

Interest and Involvement with Computer Activities

Children's responses to the computer represented a predictable pattern, ranging from mere curiosity to strong interest, accompanied by mixed abilities to use the experience to meet their unique interests. A few spent no more than five to ten minutes a session on the computer. At the other end of the spectrum, some children maintained an enthusiasm for their activities on the computer that stretched the limits of what we were offering them. These computer enthusiasts taught each other, learned from each other, and used the adult resources their own way. They could spend up to an hour moving through various computer tasks and circu-

lating within the computer area, engaging in computer discussions with others.

As expected, those who gained increasing control with LOGO commands tended to spend longer and longer periods at the computer over the weeks, but none spent the complete 90-minute session at this activity. Of the 22 children who participated in the first two cycles, one half demonstrated sufficient interest and mastery to continue for an additional eight-week cycle. Our primary criterion for selection to continue was the degree of interest in computer activities, irrespective of the level of mastery of LOGO commands. Two of the 11 in this last cycle evidenced a fascination with the computer and its working parts that drove them to explore all kinds of keying combinations unrelated to Keystroke LOGO or the software package. Throughout the sessions, we continued to explore strategies to discover what kinds of computer activities might channel this curiosity to their satisfaction.

During the final eight-week cycle with the experienced group of children, we experimentally introduced some of the software that had originally been rejected. While the children tested them extensively, once their curiosity was satisfied, they tended to return to the more open-ended activities of LOGO and Kindercomp DRAW.

Children's Computer Learnings

Our judgments about children's computer learnings are based on observations of how they spent their time, and what they chose to talk about with us and the other children. In the process of mastering the basic LOGO drawing commands, they engaged in thinking about a broad range of introductory geometric ideas. The children talked about and worked on (a) line-direction and turning-direction, (b) distance, (c) location as "inside-outside," (d) position as "up and down" or "at the side," (e) reversing turning-direction as well as reversing drawing-direction to trace over a line, and (f) identifying and using attributes of geometric shapes. Initially they struggled with the difference between movement, as in drawing a line, and pivot, as in a turn. They did not use "right-left" labels and they struggled with mastery over turning directions.

A few children tried regular LOGO, which required using numbers to specify length of line, but quickly returned to Keystroke when they did not need to alter the fixed distance of the keystroke line. Essentially, the children were not able to think in terms of more than one command at a time, and therefore we did not stretch toward writing procedures.

Several children did, however, develop the ability to plan a drawing by creating it first on paper. Others copied some of their computer drawings, using crayons. Children increasingly carried their computer interest with them, as they moved to the concrete materials. They also reversed this pattern by creating on-screen replications of block structures. The capacity to print screen pictures fascinated only a few children.

When the final group of children acquired experience with the additional software, they became articulate about their views of "good" and "bad" programs. In our setting, which provided many choices, they expressed their software evaluations spontaneously. When we interviewed them about these judgments, they indicated growing competence as software reviewers, explaining specifically, as software reviewers would do, how the limits of the program were frustrating to them.

Cumulative learning was evidenced by the fact that children often arrived announcing that

they wanted to try out something they had just learned last week, or had been working on before. Similarly they left us with a reminder of what they planned to do next time.

After several sessions with LOGO, we introduced Kindercomp DRAW. The children approached the drawing task as if it were a LOGO program, with a clear sense that they were in control, demonstrating a "planfulness" that had already been developed manipulating the LOGO turtle.

For the parents, the most impressive part of the children's learning was the children's obvious comfortableness with the computer. Parents of the more adept children were also impressed by their child's enthusiasm for learning new things and obvious pride in showing what they can do.

The most impressive parts of the children's learnings for the researchers were the intensity and persistence evidenced by some of the children as they worked on their chosen computer tasks, and how they bridged between the three-dimensional and the two-dimensional world.

The Computer-room as a Learning Environment

Irrespective of the amount of time spent at the computer, all children utilized the environment as an educational experience, in the traditional early childhood view. They selected materials, developed their own learning tasks, socialized, and exchanged ideas and suggestions for using the materials. They also shared their successes and failures with each other and the adult, and essentially developed a sense of belonging, either through friendship with one other child or with the larger group. Children used the off-computer activities in three important ways: (1) they experimented with some ideas about direction, distance, form and structure, geometric shape, and number that had captured their attention at the computer; (2) they sought a sense of control over materials and events that they could not achieve initially as they used the computer; and (3) they used the materials as a prop to extend social interchanges.

The computer-room environment, in which some children were simultaneously working at computers (initially on different LOGO activities, and later with different programs), produced a kind of stimulation between children that fed their interest and increased their competence. This stimulation was manifest in several ways. As children approached the teachers with such statements as, "I need help," other children would stop what they were doing to pitch in, or watch and learn. Interestingly, the volunteer peer-helpers and curious learners might come from the block area just as readily as from the computer area. Another form of stimulation occurred as children walked around to observe what others were achieving on the computer. We would hear such questions as "How did you do that?" as they pointed to a specific area of the screen. Usually, children did *not* choose to work together on computers, although they frequently chose to show others (including teachers) their accomplishments and discuss what they were doing. When they were involved in exploring, experimenting, and creating at the computer, they resisted any intrusion by other members of the group. When interrupted, they would say, "Wait," or physically signal their preference to work alone.

By chance, we found a major exception to this preference to work alone. When one of the children discovered the skill-drill programs of Kindercomp, others clustered around the computer, expressing excitement when the colorful graphics "reward" appeared. Considerable competition soon appeared between children, as

they sought to press the key that produced the "rainbow." This tutor or drill type of program required more management strategies from the teachers, while the interactive programs required more of the instructional strategies.

It is our judgment that the off-computer activities, both the open-ended traditional classroom materials and the structured boardgames, combined with the freedom of choice, were essential to the achievement of the richness of the activity we observed and the eagerness with which the children came, stayed, and participated. Based on our experiences to date, it is our hunch that a computer-room that is limited to computers would create a stressful condition, since children would not have the opportunity to articulate their experiences between the three-dimensional world over which they have some mastery, and this new form of two-dimensional world. Our initial impression from this study is that much of the potential for learning grows out of children's movement between different media and materials as they work through an idea.

Summary and Recommendations

After working with two different groups of five-year-olds in a modified computer-room, one for eight sessions (a total of 12 hours), and another for 12 sessions (24 hours), we now know that some five-year-olds can thrive as learners in a setting in which certain conditions exist. The answer to the question of whether the computer can be used to help meet curriculum goals is "Yes," for these given conditions. If curriculum goals include increasing skill in manipulating variables and achieving mastery in using the materials in the environment, computer use can serve such goals for some kindergarten children. The question about which computer experiences will serve these goals can also be answered. Computer activities in which the command system is sufficiently simple and directly related to events on screen offers the opportunity for children to experiment and learn on their own terms.

We also know that nonreaders and young children with overriding interests in the three-dimensional world are not likely to use the computer as more than a novelty toy. If they are required to do so under structured conditions, it is doubtful that any curriculum goals can be met, considering the probable frustration that will result.

While not yet recommending a specific model for computer use by kindergarten children, we are able to suggest a set of conditions that have been documented as engaging and sustaining the learning energies of *some* children, and therefore can be recommended as a guide for the development of one model. These are:

1. Children have choices, to use the computer or other appropriate early childhood materials.
2. Children may use the computer alone, without demands to share during the actual use time.
3. A variety of computer activities are available.
4. At least two computers are provided, so that there can be interaction between children simultaneously working on computer activities.
5. A printer is available for making hard copies of the children's work.
6. A knowledgeable computer-user who also understands the way young children learn is actively supervising the children's computer experiences.
7. There is a maximum teacher-child ratio of one teacher to five children.

Clearly, differing theoretical approaches to child development and learning will steer us in different directions as the research evidence ac-

cumulates. For those early childhood professionals who share our conviction that young children learn best in a varied, action-based learning environment, and need to process learnings in their own terms, the kind of computer experiences described in this study will conform with such a commitment. Remaining to be addressed is the bigger question of whether the considerable funds spent to support such high-cost technology should be directed toward such other important components as increased personnel and expanded services.

A Final Statement

Based on the findings of this exploratory study, this researcher takes the position that *microcomputers do not yet belong in early childhood classrooms serving three-to-six-year-old children.*

From our select group of 22 children having high interest parents, only one half showed more than a passing interest in the computer activities we provided. Since our experience indicates that the children who are most able to utilize the computer to feed their interests are those who can read, the use of the microcomputer CANNOT serve the curriculum goals for a sufficient number of prekindergarten and kindergarten children to justify the expense. The high initial-purchase cost, the teacher-training costs, and the sustaining-personnel costs are exorbitant, when viewed in terms of the low percentage of children at this age ready to use the technology as more than a novelty toy.

Although we have documented that some beginning readers within this age group can effectively use the microcomputer as "grist for their learning mill," nothing would be lost by waiting until they are older. As eight- or nine-year-olds, these same children could learn to use worthwhile programs, such as LOGO, with less need for the costly, low teacher-child ratio required for successful computer experiences at age five.

While this researcher does not share the more popular early childhood view that computer experiences occurring under the conditions described can damage developmental learning styles, it seems clear that in the normal prekindergarten and kindergarten classroom with current teacher-child ratios, the computer will be used only peripherally by most children. The computer laboratory approach is equally unpromising at this time. Very few settings can afford the time and personnel to meet the guidelines set forth in the prior section.

Our next step in research is to experiment with more groups, including six- and seven-year-olds, extending the number of exposures, trying different cycling patterns, and finding out more about the relationship between what children bring to the experience and how they use the material.

We do not yet have the answer to the question of when to integrate computers into school programs. Although there are a few children who can use computer experiences to enrich their learning during the early childhood years, it seems clear to this researcher that, for now, placing computers in early childhood classrooms is not an appropriate use of limited school resources.

Notes

1. This paper is based on one presented at the National Conference on Computers and Young Children, University of Delaware, April, 1984, *Microcomputers and Young Children: Using Research to Plan Programs.*

2. One of the most recent and comprehensive statements of this position appears in the Summer 1984 Issue of *Teachers College Record*, "Microcomputers in Education: Why is Earlier Better?", by Harriet Cuffaro of Bank Street College of Education.

Other titles beg the same question: Hill (1984), *Beware of Bandwagons: Young Children May Not Need Microcomputers;* Bowman (1983), *Do Computers Have a Place in Preschools?*

3. In addition to the views expressed by the authors cited in footnote 2 above that young children are not developmentally ready to engage in worthwhile computer activities, Broughton sees more insidious effects of computer education, not only for early childhood but through the grades. He posits that the high valuing of logical thinking in computer use constitutes a "hidden curriculum" which creates an instructional condition in which the ultimate goal is to devalue subjectivity and "peruse a form of thought that requires a symbiotic relationship to an ingeniously intrusive high technology device."

4. It should be noted that some researchers are looking at special applications of computer use with young children. Trachtman (1984), e.g., discusses some of the promising studies related to using computers with speech-impaired children.

5. Typical early childhood teacher education books detailing children's learning behavior with traditional prekindergarten and kindergarten classroom materials are: Katherine Read's *The Nursery School: Human Relationships and Learning*, and *Exploring Teaching in Early Childhood Education* by Helen Robinson.

6. Taylor, 1980.

7. In his book *Mindstorms*, Seymour Papert initiated the idea of the child's teaching the computer; and it has been repeated so often in the literature that it is rarely questioned. The notion is that once the child learns the basic LOGO commands, he or she can write procedures that create new commands, i.e. teach the computer how to do something new, such as make a square.

8. See especially Asbell (1984), Kramer (1984), Lawler (1982), Paisley and Chen (1982), Piestrup (1981).

9. Mrs. Rochelle Leibson is currently Computer Coordinator, New York City Community School District 28, Queens. Before taking this position, she initiated the computer program for the early childhood grades in her school, and helped teach the Queens College Saturday morning computer classes serving children 5–12 years of age.

10. There are many excellent summaries of the cognitive developmental theory. One such summary may be found in Forman and Kuschner, *The Child's Construction of Knowledge*. An analysis of application of these ideas to computer research was presented by Barbara Bowen at the 1984 meeting of the American Educational Research Association.

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Afterword
Technology Use in School Settings: Second-Generation Probes

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Computers for *what*?

It has taken a decade (1975-1985), but now at last we see signs that the first generation of "messing about" with computers in school settings is coming to an end. Educators are beginning to respond to the charge raised by Douglas Sloan:

> Scrambling to lead the van of the computer-communications revolution in education, American educators have made no concerted effort to ask at what level, for what purposes, and in what ways the computer is educationally appropriate and inappropriate, in what ways and to whom we can count on its being beneficial or harmful. The overall picture has been one, instead, of educators vying to outdo one another in thinking of new ways to use the computer in all manners and at every level of education possible. Professional responsibility demands more.*

Sydney Schwartz, in her study "Microcomputers and Young Children," offers a prime example of a *new* agenda being followed by a second generation of investigators. The broad issue addressed by this new agenda is the question: Under what circumstances can the tools of modern technology provide a more effective, cheaper, or faster means of meeting curriculum objectives? Specifically, you will recall, she asks, "Can computer experiences engage and sustain the attention of young children as active learners? If so, what classroom conditions seem to be associated with successful involvement of the children?" Her conclusion is that activities involving the use of computers can stimulate the cognitive development of young children, but only under extraordinary conditions not easily available in ordinary classrooms. That conclusion is rational, sound, and supported by the evidence that she and her colleague Rochelle Leibson gathered. Another analysis of the study, however, generates two additional generalizations: (1) The concept of "design boundaries" provides a useful model for planning and developing a wide range of technology-related experiences. (2) Making critical decisions with respect to the use of technology in classrooms requires a sound understanding of the knowledge base of education. Staff development efforts need a major restructuring in tune with the principle that knowledge of technology should follow knowledge of the teaching process.

Let's examine these two points in greater detail.

First Priority: Educational, Not Technological Decision-making

How shall we design a technology experience—a class, a workshop, a course, or a research study? Professor Schwartz responds by redirecting priorities back to the teaching-learning process. Using the concept of design boundaries, she outlines three fundamental conditions that must be met prior to technology decisions:

1. A statement regarding target-learner characteristics. *(Choose computing experiences that conform to this description.)*

2. A specification of the curriculum objectives. *(Choose computing activities that pursue these objectives.)*

3. A description of teaching strategies and instructional conditions through which the objectives will be met. *(Choose computing environments that relate realistically to those strategies.)*

An analysis of the Schwartz study provides a

*Douglas Sloan. "On Raising Critical Questions about the Computer in Education." *Teachers College Record*. Vol. 85, No. 4, Summer, 1984.

helpful paradigm of how these design-conditions can be met.

Learner characteristics. Three-to-six-year-olds are mostly nonreaders. Dependent on the appearances of things, they have limited understanding of causal relationships. They use animistic thinking to explain events, and have extremely limited ability to link multiple events.

Curriculum objectives. Teachers of young children need to pursue two interrelated goals: (1) to stimulate the children's thinking and (2) foster their ongoing cognitive development.

Teaching strategies and instructional conditions. Since children learn best when given the opportunity to choose, from attractive options, what they want to learn, a varied action-based environment is needed. They can then process learning on their own terms. Teachers' functions in such settings might include responding to individual requests, intervening with suggestions, attending to social-emotional needs, and exercising standard classroom-management techniques.

These three design-characteristics dictated the "technology" decisions. LOGO, Kindercomp, and Moptown Parade were selected as hardware appropriate to the nature of the learners and consistent with the curriculum objectives. Hardware was available in sufficient quantity so that students could work alone if they chose to.

Explicitly describing the fundamentals of the teaching-learning process up front had another consequence. The design characteristics highlighted the need to make several "nontechnology" decisions important to the success of the experience. To carry out the functions required of multiple-activity classrooms, a low teacher-student ratio was chosen. To allow the students to exercise choice among attractive options, familiar early childhood classroom materials (blocks, crayons, puppets, etc.) were provided.

Implications of Second-Generation Agenda

The Schwartz study calls attention to the need to redirect priorities back to the teaching-learning process. Teachers at all levels must be capable of thinking deeply and systematically about what they are doing (or plan to do) in the classroom and why they are doing it. At a minimum, teachers must be capable of describing design-boundary conditions appropriate to their audience. Our best staff development efforts in school use of technology will be organized by those educators capable of helping others clarify these fundamental pedagogical concerns.

Third-Generation Agenda

Even as second-generation inquiries gather momentum, third-generation probes into technology use in school settings are beginning. These Generation-III activities are rooted in the conviction that effective growth and learning cannot occur without schools providing, as a first requirement, conditions where *teachers'* needs are met. Computer technology may find its most profound use here—a strategic vision along these lines would make the tools of technology available to assist teachers in every management task so as to provide the healthy ecology for second-generation concerns to proceed. But this is another topic for another time.

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